Superdeformation in the $N = Z$ Nucleus ^{36}Ar

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High-spin states in the $N = Z$ nucleus ^{36}Ar were studied via the ^{28}Si(^{16}O,2α)^{36}Ar reaction, with a 75-MeV ^{16}O beam provided by the ATLAS facility at Argonne National Laboratory. Gamma rays were detected with 101 HPGe detectors of the Gammasphere array, in coincidence with charged particles detected with the Microball, a 4π array of 95 CsI(Tl) scintillators.

This experiment led to the identification of a superdeformed band in ^{36}Ar, the first such band in the $A \sim 30$–40 mass region. The γ-ray spectrum obtained by summing coincidence gates set on the members of the band is shown in Fig. 1. It is observed to its presumed termination at $I^\pi = 16^+$ and the high-energy transitions denoted by diamonds in Fig. 1 firmly link the band to known low-spin states.

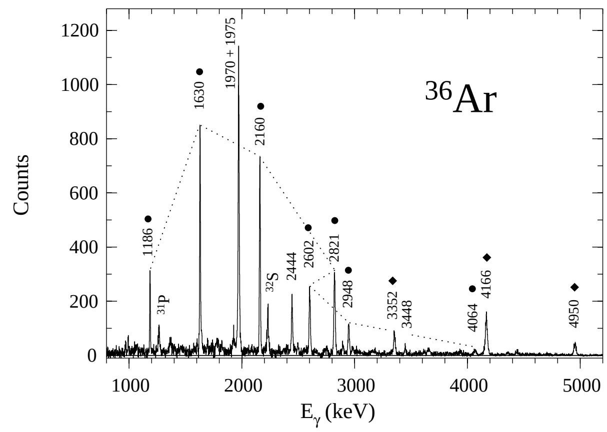

Figure 1: Gamma-ray spectrum obtained by summing coincidence gates set on the transitions in the ^{36}Ar superdeformed band. The dotted line connects the in-band transitions (circles) and diamonds indicate linking transitions.

We have performed both cranked Nilsson-Strutinsky and spherical shell model calculations for the ^{36}Ar band. The former calculations lead to a configuration assignment in which four fp intruder orbitals are occupied. At low-spin, a prolate shape with deformation $\beta_2 \approx 0.45$ is calculated. With increasing spin the nucleus is predicted to change shape smoothly, with the band terminating at $I^\pi = 16^+$ in a fully-aligned oblate state. The shell model calculations employed the $(s_{1/2}d_{3/2}f_{7/2}p_{3/2})^8$ model space and confirmed the dominantly $(fp)^4$ configuration. These calculations also suggest that consideration of the entire sd shell will be essential for a complete microscopic account of the large quadrupole collectivity of this band. With active protons and neutrons in both the sd and fp shells, the ^{36}Ar band provides an ideal opportunity to bridge the gap between the well-studied, but unusual, single-shell rotors like ^{20}Ne and ^{48}Cr, and a more general microscopic description of rotational motion in nuclei. It is hoped that these results will motivate larger-scale shell model calculations in an attempt to achieve a complete microscopic description of the ^{36}Ar band. Experimental lifetime measurements (in progress) will provide stringent tests of the quadrupole properties predicted by such calculations.